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Park**

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(54) **MEMORY SYSTEM HAVING IMPROVED  
SIGNAL INTEGRITY**

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**G11C 5/06** (2006.01)

(52) **U.S. Cl.** ..... **365/63; 365/51**

(58) **Field of Classification Search** ..... 365/63,  
365/51  
See application file for complete search history.

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(57) **ABSTRACT**

A memory system having improved signal integrity includes a printed circuit board for use in a memory device, N memory semiconductor packages mounted on the printed circuit board, a first switch mounted on the printed circuit board, a controller mounted on the printed circuit board, N first signal lines connecting the semiconductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence, a second signal line connecting the first switch to the controller, and N selection lines connecting the semiconductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence. The N selection lines connect the semiconductor packages to the controller and transmit an enable signal. N is a natural number.

**11 Claims, 11 Drawing Sheets**

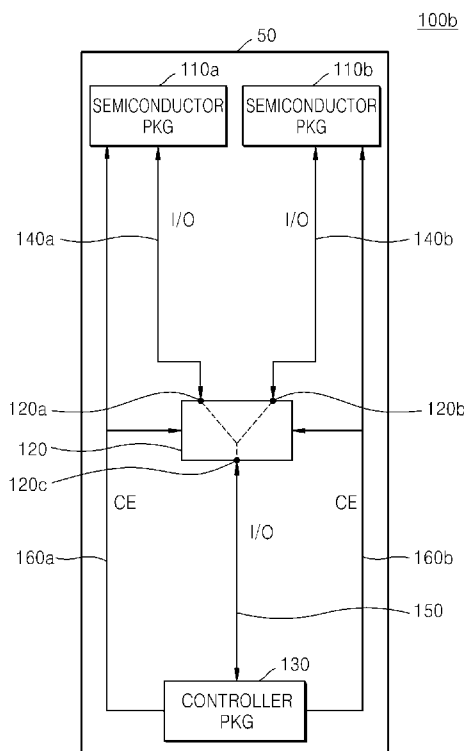


FIG. 1A

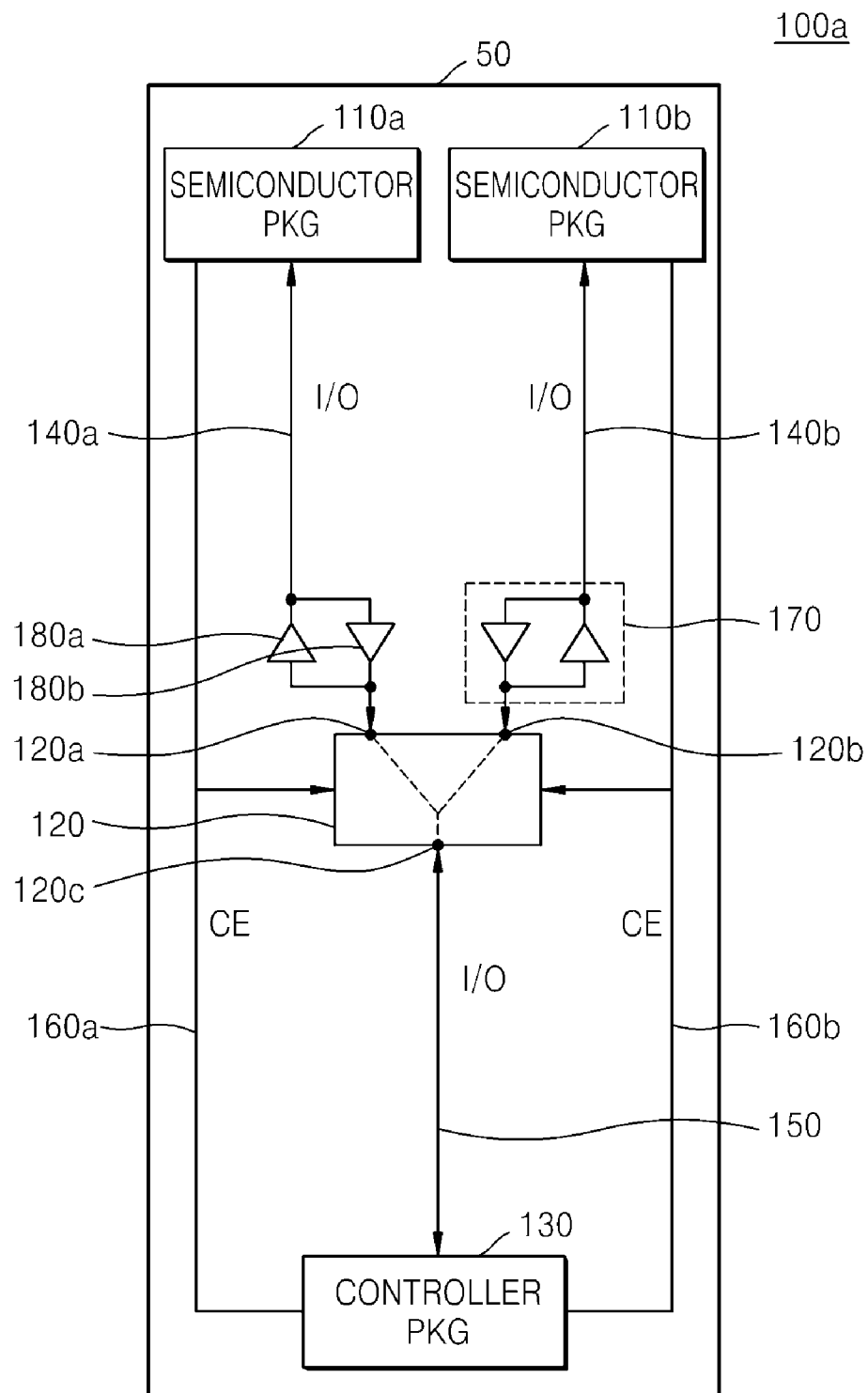


FIG. 1B

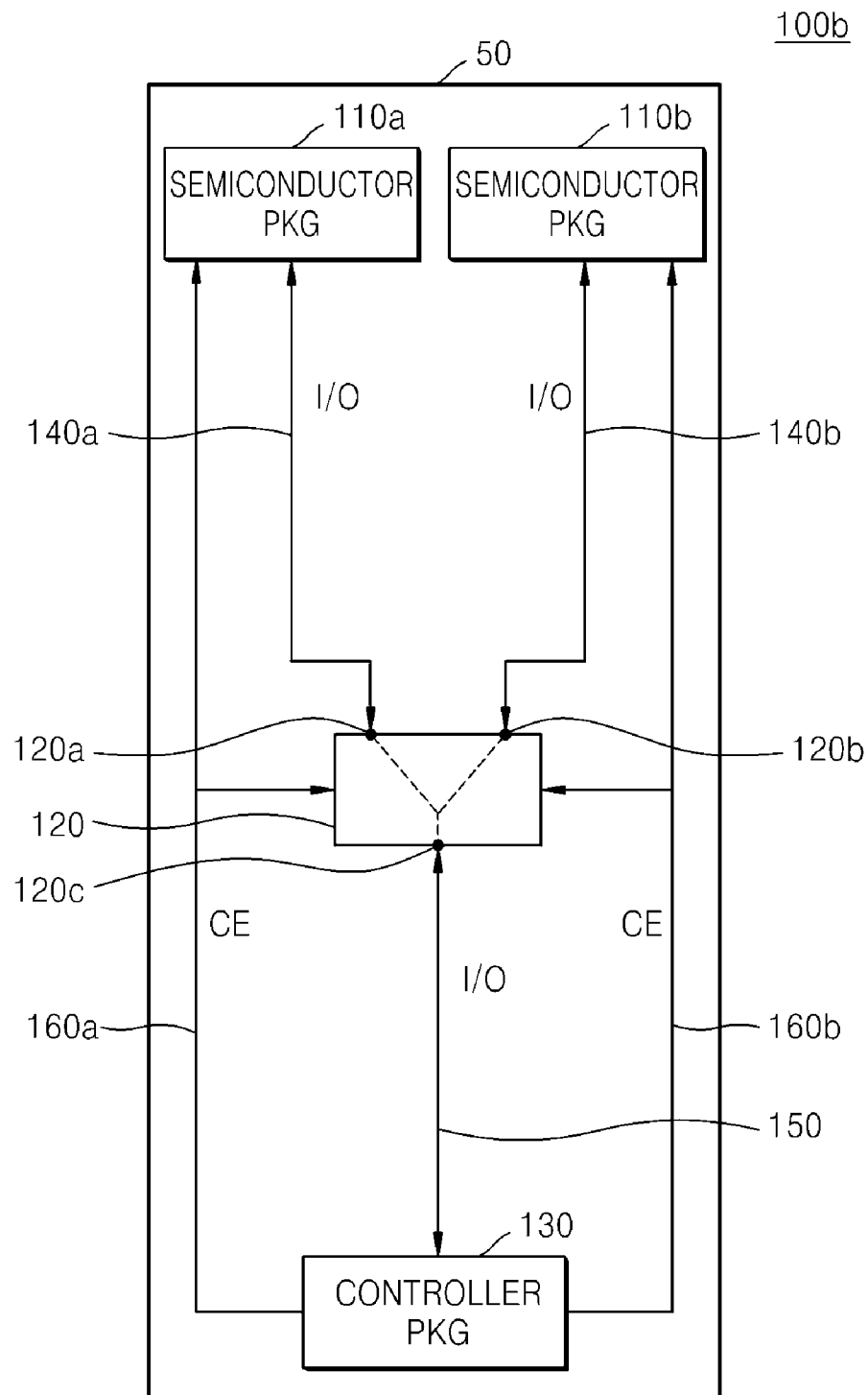


FIG. 1C

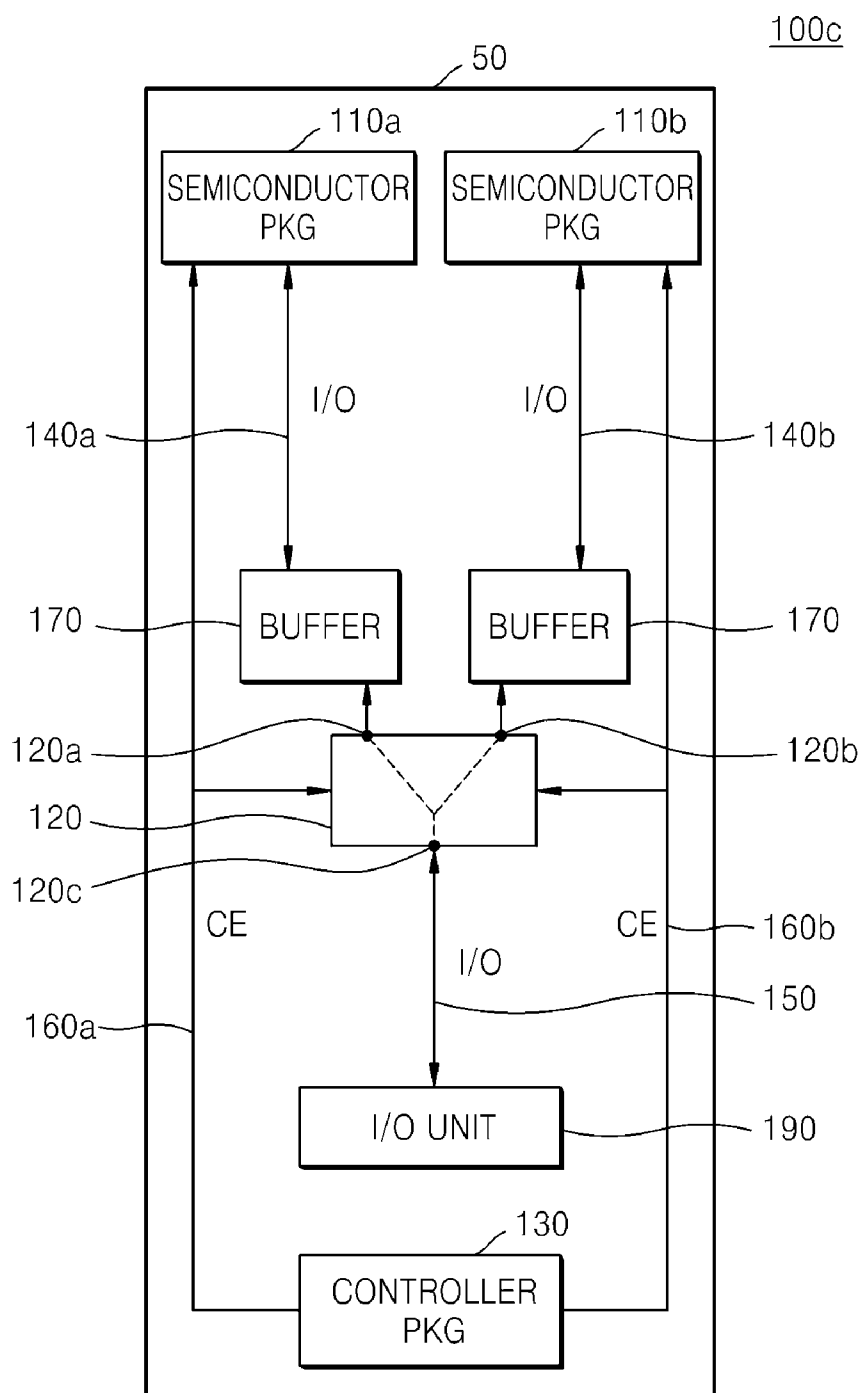


FIG. 1D

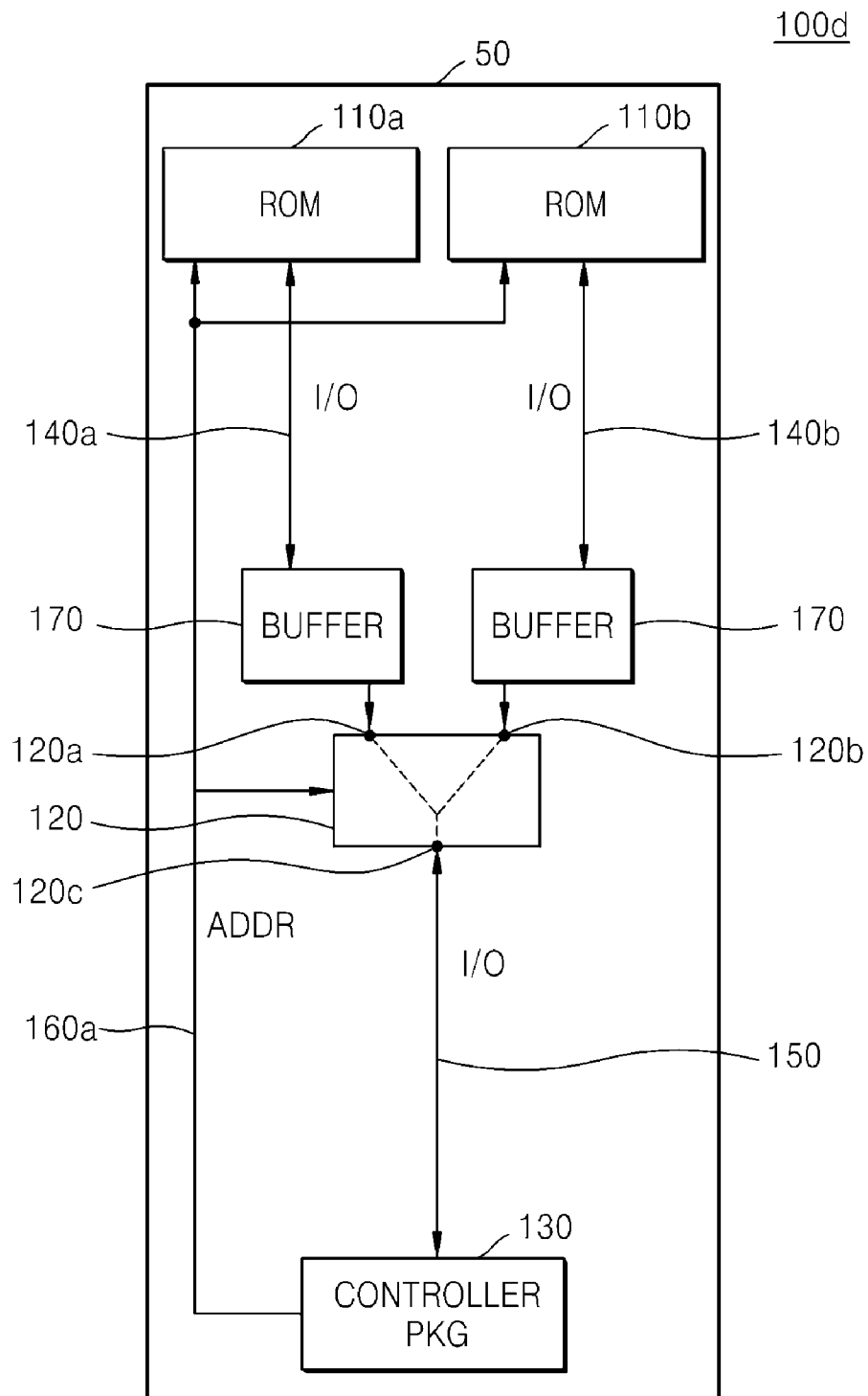
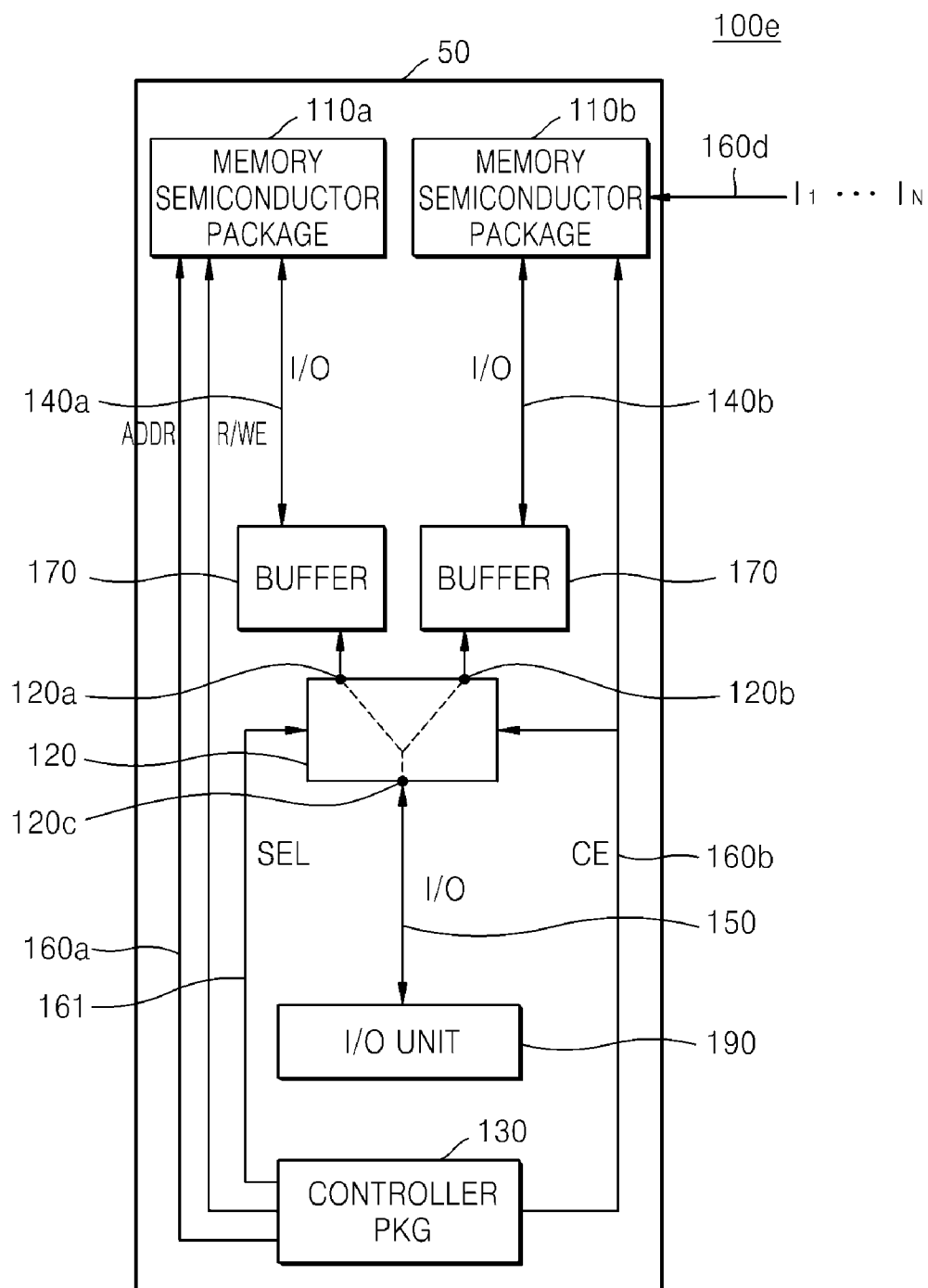


FIG. 1E



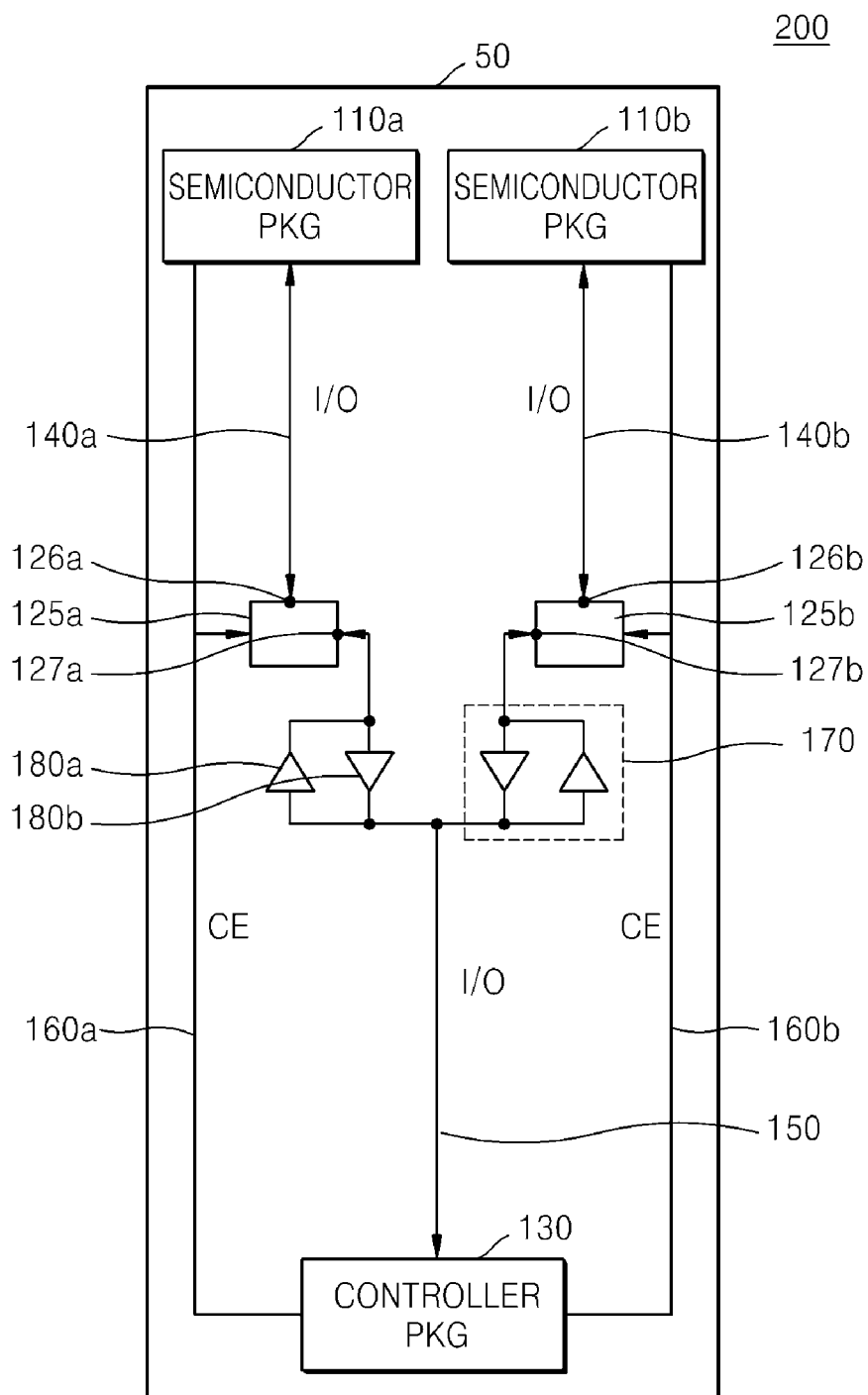


FIG. 3

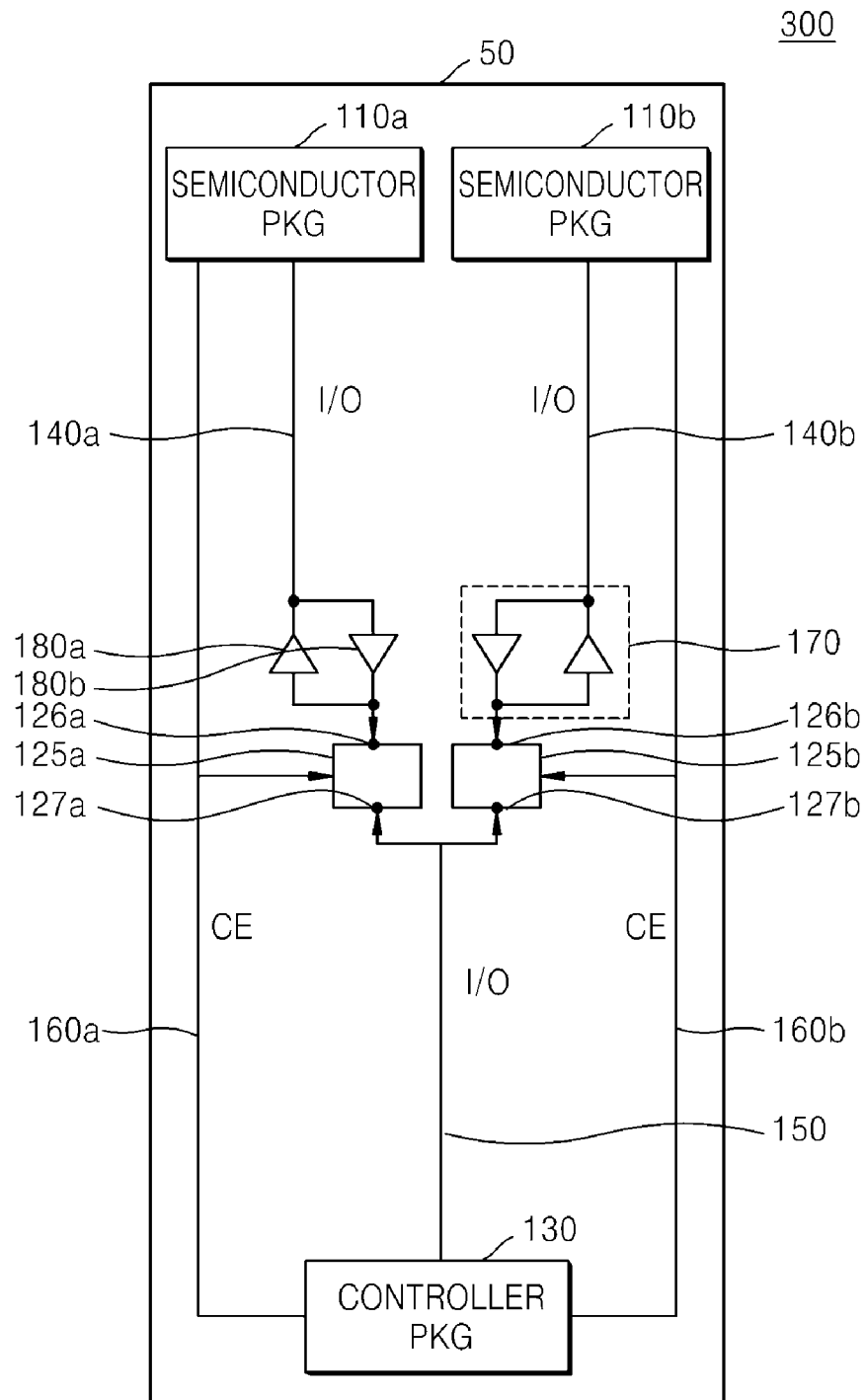




FIG. 4

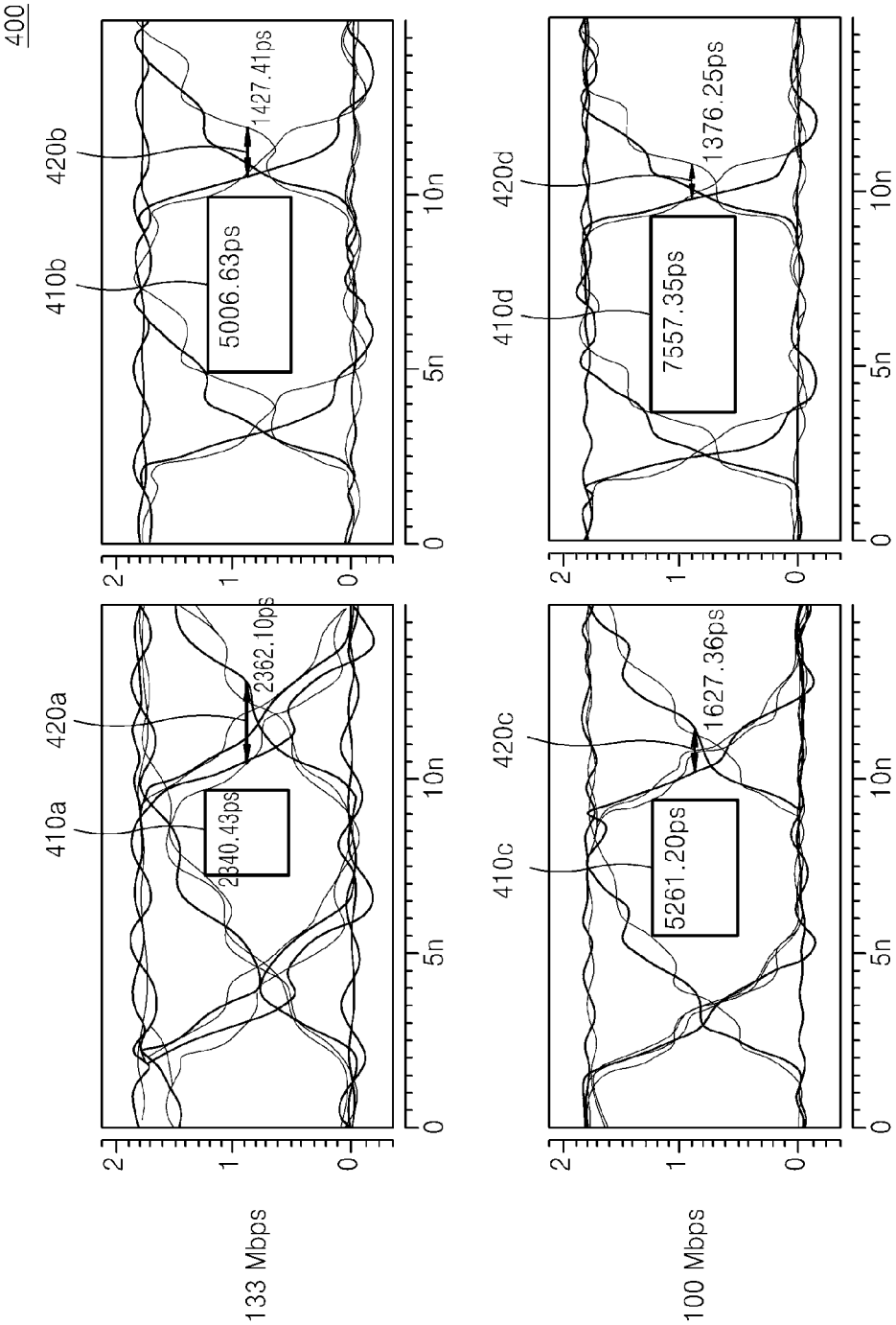


FIG. 5

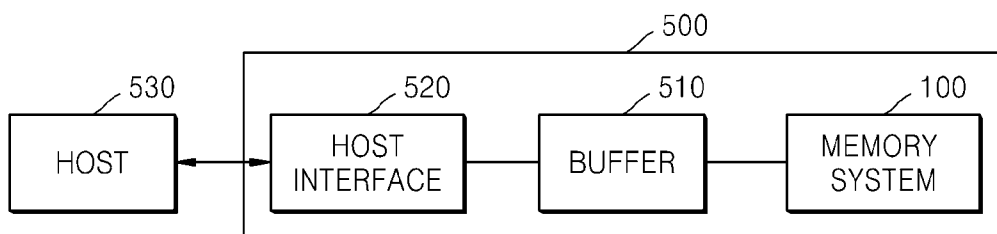


FIG. 6

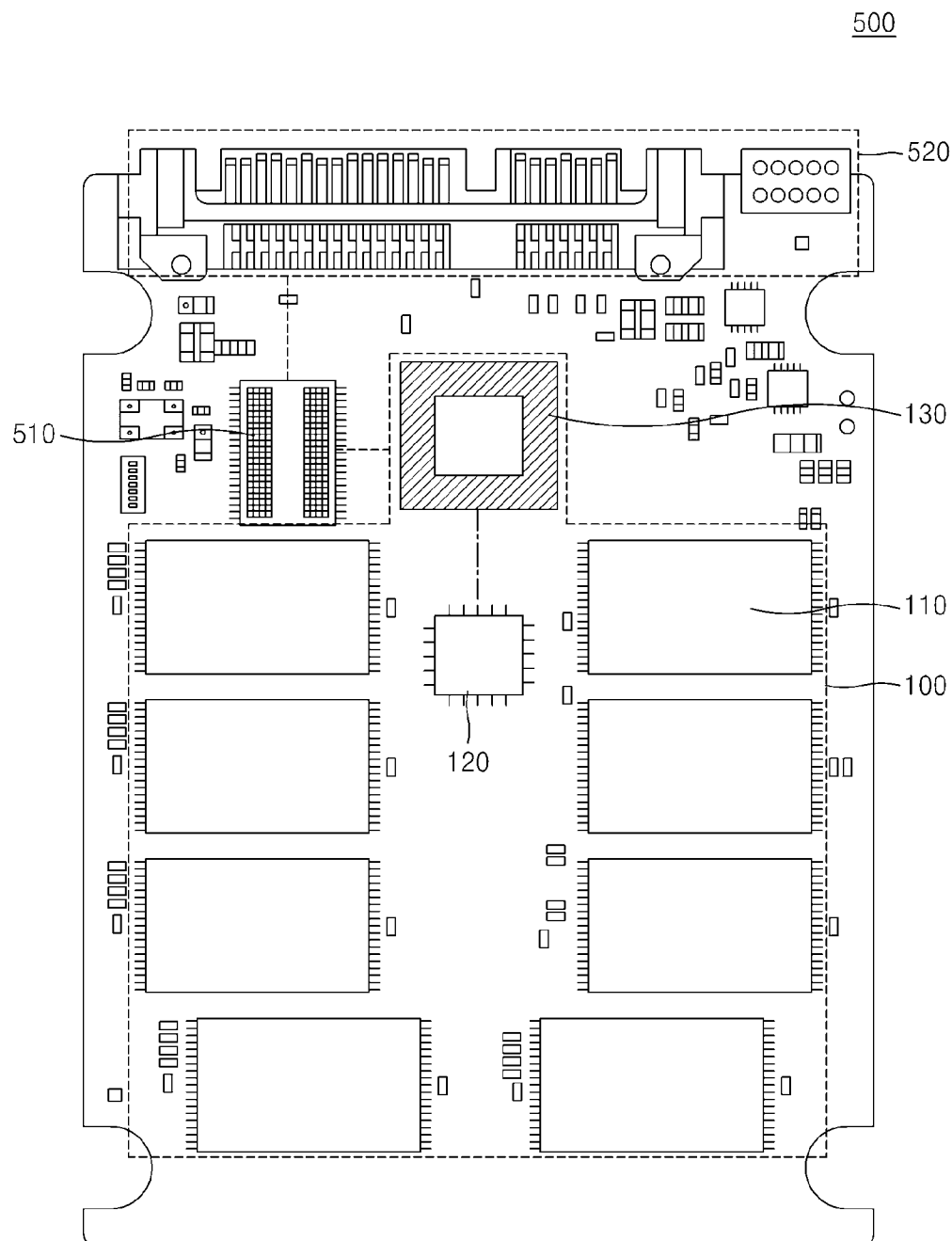


FIG. 7

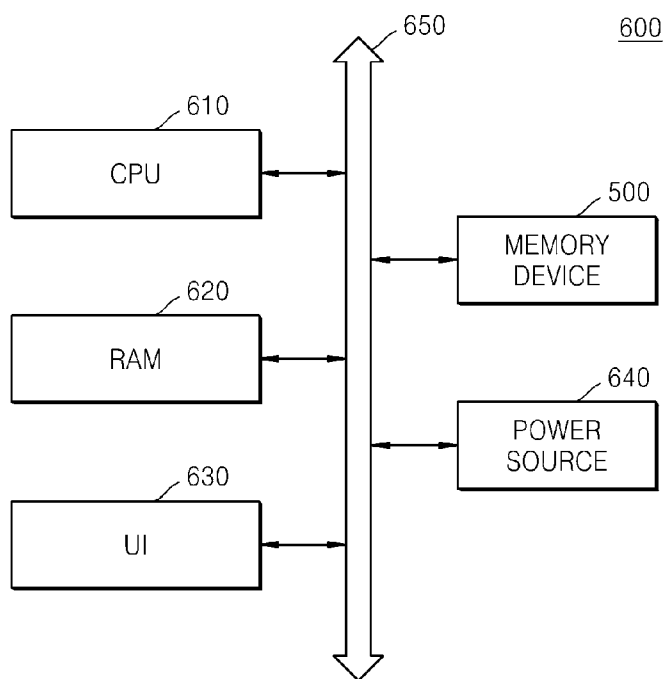
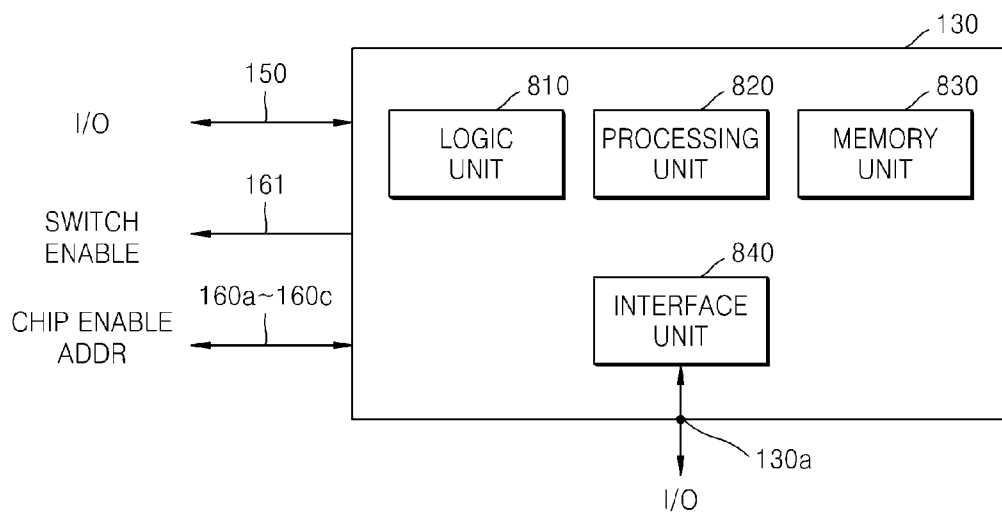


FIG. 8



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# MEMORY SYSTEM HAVING IMPROVED SIGNAL INTEGRITY

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119 of Korean Patent Application No. 10-2009-0072827, filed on Aug. 7, 2009, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

## BACKGROUND

### 1. Field of the Invention

The present general inventive concept relates to a memory system, and more particularly, to a memory system having increased storage capacity in a high-speed operating environment.

### 2. Description of the Related Art

In general, electronic products, such as memory devices, require high-speed data processing. Thus, various methods have recently been introduced to increase operating speeds. In particular, a maximum operating speed of NAND flash memory for use in storage devices, such as solid state drives (SSDs), may be up to 40 Mbps. Also, research is being conducted into development of NAND flash memory that can operate with a maximum data throughput of 133 Mbps.

However, not only an operating speed but also the total number of memory chips to be connected to the same signal line, i.e., the same channel, is a very important factor in NAND flash memory for use in storage devices, such as SSDs. This is because the more memory chips are connected to the same signal line, the greater the storage capacity of NAND flash memory.

However, in a conventional signal line topology, if an operating speed and the total number of memory chips that are to be connected to the same signal line are both increased, then signal integrity may be degraded due to loading effects between a driver and a receiver. That is, input capacitance increases when a frequency is increased in order to increase an operating speed, and load on the system increases when the total number of memory chips that are to be connected to the same signal line is increased, thereby causing a resistance-capacitance (RC) delay to occur.

## SUMMARY

The present general inventive concept provides a memory system and a memory device, in which an operating speed and the total number of chips that are to be connected to the same signal line can be increased at the same time.

Additional aspects and utilities of the present general inventive concept will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the general inventive concept.

Features and/or utilities of the present general inventive concept may be realized by a memory system including a printed circuit board, N memory semiconductor packages mounted on the printed circuit board, a first switch mounted on the printed circuit board, a controller mounted on the printed circuit board, N first signal lines connecting the semiconductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence, a second signal line connecting the first switch to the controller, and N selection lines connecting the semicon-

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ductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence. The N selection lines may also connect the semiconductor packages to the controller such that semiconductor packages and the controller are in an N-to-1 correspondence, and may transmit an enable signal, wherein N is a natural number.

The first switch may include an N-to-1 multiplexer receiving the enable signal and electrically connecting one of the first signal lines to the second signal line.

The memory system may further include N bi-directional buffers connecting the first signal lines to the first switch such that the first signal lines and the first switch are in an N-to-1 correspondence.

Each of the N bi-directional buffers may include a first repeater having an input terminal connected to the first switch and an output terminal connected to one of the first signal lines, and a second repeater having an input terminal connected to the same first signal line and an output terminal connected to the first switch.

The memory device in which the printed circuit board is to be used may include a solid state drive (SSD), a memory module, a memory card, a memory semiconductor package, or a combination thereof.

Features and/or utilities of the present general inventive concept may also be realized by a memory system including a printed circuit board, N memory semiconductor packages mounted on the printed circuit board, N second switches mounted on the printed circuit board, a controller mounted on the printed circuit board, N first signal lines connecting the semiconductor packages to the second switches, respectively, such that the semiconductor packages and the second switches are in a 1-to-1 correspondence, a second signal line connecting the second switches to the controller, and N selection lines connecting the semiconductor packages to the second switches, respectively, such that the semiconductor packages and the second switches are in a 1-to-1 correspondence. The N selection lines may also connect the semiconductor packages to the controller such that semiconductor packages and the controller are in an N-to-1 correspondence, and transmit an enable signal, wherein N is a natural number.

One of the second switches may receive the enable signal and electrically connect one of the first signal lines to the second signal line.

The memory system may further include N bi-directional buffers connecting the second switches to the second signal line such that the second switches and the second signal line are in an N-to-1 correspondence.

The memory system may further include N bi-directional buffers connecting the first signal lines to the second switches, respectively, such that the first signal lines and the second switches are in a 1-to-1 correspondence.

The memory device in which the printed circuit board is to be used may include a solid state drive (SSD), a memory module, a memory card, a memory semiconductor package, or a combination thereof.

Features and/or utilities of the present general inventive concept may also be realized by a memory device including a memory system, a host interface, and a buffer. The memory system includes a printed circuit board for use in a memory device, N memory semiconductor packages mounted on the printed circuit board, a first switch mounted on the printed circuit board, a controller mounted on the printed circuit board, N first signal lines connecting the semiconductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence, a second signal line connecting the first switch to the controller, and N

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selection lines connecting the semiconductor packages to the first switch such that the semiconductor packages and the first switch are in an N-to-1 correspondence. The N selection lines may also connect the semiconductor packages to the controller such that semiconductor packages and the controller are in an N-to-1 correspondence, and transmit an enable signal. The host interface may be disposed on the printed circuit board and may be connected to the controller. The buffer may connect the host interface to the memory system. N may be a natural number.

Features and/or utilities of the present general inventive concept may also be realized by a memory device including a memory system, a host interface, and a buffer. The memory system may include a printed circuit board for use in a memory device, N memory semiconductor packages mounted on the printed circuit board, N second switches mounted on the printed circuit board, a controller mounted on the printed circuit board, N first signal lines connecting the semiconductor packages to the second switches, respectively, such that the semiconductor packages and the second switches are in a 1-to-1 correspondence, a second signal line connecting the second switches to the controller, and N selection lines connecting the semiconductor packages to the second switches, respectively, such that the semiconductor packages and the second switches are in a 1-to-1 correspondence. The N selection lines may also connect the semiconductor packages to the controller such that semiconductor packages and the controller are in an N-to-1 correspondence, and transmit an enable signal. The host interface may be disposed on the printed circuit board and may be connected to the controller. The buffer may connect the host interface to the memory system. N may be a natural number.

Features and/or utilities of the present general inventive concept may also be realized by a memory device including at least two semiconductor packages, a switch connected to each of the semiconductor packages via at least two first I/O lines, each first I/O line connected to a separate semiconductor package, and a controller connected to the switch via a single second I/O line and to each of the switch and the at least two semiconductor packages via an enable line. The controller may control the switch to transmit data between only one of the first I/O lines and the second I/O line.

The at least two semiconductor packages comprise memory semiconductor chips.

At least one of the semiconductor packages may include a logic semiconductor chip.

The switch may include at least two switches, each switch connected to a single semiconductor package and each semiconductor package connected to only one switch, the enable line may include at least two enable lines, and each semiconductor package and corresponding switch may be connected to a same enable line that is separate from an enable line connected to any other semiconductor chip.

Alternatively, the switch may include only one chip.

The memory device may include bi-directional buffers connected between the semiconductor packages and the switch.

The memory device may include bi-directional buffers connected between the switch and the controller package.

Features and/or utilities of the present general inventive concept may also be realized by a memory device including at least two semiconductor packages, a switch connected to each of the semiconductor packages via at least two first I/O lines, each first I/O line connected to a separate semiconductor package of the two semiconductor packages, and a controller connected to the switch via an enable line and to the at least two semiconductor packages via at least one control

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line. The controller may control the switch to transmit data between only one of the first I/O lines and the second I/O line.

The control line may include at least one of a read/write control line, an address line, and a chip enable line.

At least one of the semiconductor packages may be a logic circuit including at least one terminal to receive a data input from a device external to the memory device.

The second I/O line may be connected to at least one of a logic circuit, a memory chip, a processor, and an I/O port.

Features and/or utilities of the present general inventive concept may also be realized by a computing system including a CPU and a memory device. The memory device may include at least two semiconductor packages, a switch connected to each of the semiconductor packages via at least two first I/O lines, each first I/O line connected to a separate semiconductor package of the two semiconductor packages, and a controller connected to the switch via an enable line and to the at least two semiconductor packages via at least one control line. The CPU may control the controller to transmit data two and from the at least two semiconductor packages.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present general inventive concept will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:

The above and/or other aspects of the present general inventive concept will become apparent and more readily appreciated from the following description of the exemplary embodiments, taken in conjunction with the accompanying drawings, in which:

FIGS. 1A-1E are schematic diagrams of a memory system according to embodiments of the present general inventive concept;

FIG. 2 is a schematic diagram of a memory system according to another embodiment of the present general inventive concept;

FIG. 3 is a schematic diagram of a memory system according to another embodiment of the present general inventive concept;

FIG. 4 is an eye diagram 400 comparing signals output from a conventional memory system in which first signal lines are connected directly to a second signal line without a first switch with signals that are input to or output from one of memory systems according to embodiments of the present general inventive concept;

FIGS. 5 and 6 are, respectively, a block diagram of and a plane view of a memory device having a memory system according to an embodiment of the present general inventive concept;

FIG. 7 is a block diagram of a computing system having the memory device of FIG. 5, according to an embodiment of the present general inventive concept; and

FIG. 8 is a block diagram of a controller package according to an embodiment of the present general inventive concept.

#### DETAILED DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to the embodiments of the present general inventive concept, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present general inventive concept by referring to the figures.

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The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the present general inventive concept. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

It will be understood that, although the terms “first”, “second”, “third”, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present general inventive concept.

These embodiments of the present general inventive concept are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the present general inventive concept. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the present general inventive concept should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

FIG. 1A is a schematic diagram of a memory system 100a according to an embodiment of the present general inventive concept. Referring to FIG. 1A, the memory system 100 may include a printed circuit board 50, semiconductor packages 110a and 110b, a first switch 120, a controller 130, first signal lines 140a and 140b, a second signal line 150, and selection lines 160a and 160b.

The printed circuit board 50 may be a printed circuit board for use in a memory device. The memory device may include a solid state drive (SSD), a memory module, a memory card, a memory semiconductor package, or a combination thereof.

The semiconductor packages 110a and 110b may be mounted on the printed circuit board 50. The semiconductor packages 110a and 110b may include a plurality of memory chips, each of the memory chips having a memory cell array. The memory chips may include volatile memory chips, such as static random access memory (SRAM), dynamic RAM (DRAM), and synchronous dynamic RAM (SDRAM), and non-volatile memory chips, such as read-only memory (ROM), programmable ROM (PROM), erasable and programmable ROM (EPROM), electrically erasable and programmable ROM (EEPROM), flash memory, phase-change RAM (PRAM), magneto-resistive RAM (MRAM), resistive RAM (RRAM), and ferroelectric RAM (FRAM).

The first switch 120 may be mounted on the printed circuit board 50. The first switch 120 may sense an enable signal transmitted via the selection line 160a or 160b, and electrically connect the first line 140a or the second signal line 140b to the second signal line 150 corresponding to which of the selection line 160a or 160b transmitted the enable signal.

The first switch 120 may include an N-to-1 multiplexer that receives an enable signal from N selection lines, e.g., the selection line 160a or 160b when N is ‘2’, and electrically

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connects one of N first signal lines, e.g., either the first signal lines 140a or 140b when N is ‘2’, to the second signal line 150.

The controller package 130 may be mounted on the printed circuit board 50. The controller 130 may control an enable signal transmitted via the selection line 160a or 160b and a data signal transmitted via the first or second signal line 140a or 140b. In detail, the controller 130 may generate the enable signal and select the semiconductor package 110a or 110b. Also, the controller 130 may store a data signal in the semiconductor package 110a or 110b respectively and may load a data signal from the semiconductor package 110a or 110b via the first or second signal line 140a or 140b.

The controller 130 may include a control logic unit (not shown) in order to control the overall operations of the memory system 100. The control logic unit may include, for example, a read/write circuit that stores a data signal in the semiconductor package 110a or 110b or loads a data signal from the semiconductor package 110a or 110b, and an address decoder that decodes an address received from the outside and provides the decoded address to the read/write circuit.

N first signals may connect N semiconductor packages to the first switch in an N-to-1 correspondence. For example, when N is ‘2’, the first signal lines 140a and 140b may connect to the first switch 120 in a 2-to-1 correspondence. The first signal lines 140a and 140b may deliver a data signal to be stored in the semiconductor package 110a or 110b or to be loaded from the semiconductor package 110a or 110b.

The second signal line 150 may be connected between the first switch 120 and the controller 130. The second signal line 150 and the first signal lines 140a or 140b may be electrically connected via the first switch 120. The second signal line 150 may deliver a data signal transmitted via the first signal line 140a or 140b to the controller 130 and vice versa.

N selection lines may connect N semiconductor packages to the first switch 120 in an N-to-1 correspondence. For example, when N is ‘2’, the selection lines 160a and 160b may connect two semiconductor packages 110a and 110b to the first switch 120, so that two semiconductor packages 110a and 110b and the first switch 120 are in a 2-to-1 correspondence. The N selection lines may connect N semiconductor packages to the controller 130 in an N-to-1 correspondence. For example, when N is ‘2’, the selection lines 160a and 160b may connect two semiconductor packages 110a and 110b to the controller 130, so that two semiconductor packages 110a and 110b and the controller 130 are in a 2-to-1 correspondence. The selection lines 160a and 160b may transmit a plurality of enable signals generated by the controller 130 to the semiconductor package 110a and 110b, respectively.

For example, if N selection lines, e.g., the selection lines 160a and 160b when N is ‘2’, are respectively connected to N semiconductor packages, e.g., the semiconductor packages 110a and 110b when N is ‘2’, then an enable signal transmitted via the selection line 160a, which is located leftmost among the selection lines 160a and 160b, may go low. In this case, the first switch 120 may sense the enable signal transmitted via the selection line 160a and electrically connect the first signal line 140a, which is located leftmost among the first signal lines 140a and 140b, to the second signal line 150. Thus, a data signal may be stored in or be loaded from the semiconductor package 110a, which is located leftmost among the semiconductor packages 110a and 110b.

Likewise, if N selection lines, e.g., the selection lines 160a and 160b when N is ‘2’, are respectively connected to N semiconductor packages, e.g., the semiconductor packages 110a and 110b when N is ‘2’, then an enable signal trans-

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mitted via the selection line **160b**, which is located in rightmost among the selection lines **160a** and **160b**, may go low. In this case, the first switch **120** may receive the enable signal transmitted via the selection line **160b** and electrically connect the first signal line **140b**, which is located rightmost among the first signal lines **140a** and **140b**, to the second signal line **150**. Thus, a data signal may be stored in or be loaded from the semiconductor package **110b**, which is located rightmost among the semiconductor packages **110a** and **110b**.

When the first signal lines **140a** and **140b** are connected directly to the second signal line **150** without the first switch **120**, the semiconductor packages **110a** and **110b** should be considered to determine equivalent resistances of all components connected to the controller **130**. Also, the semiconductor packages **110a** and **110b** should be considered to determine equivalent resistances of all components connected to each of the semiconductor packages **110a** and **110b**.

However, in the current embodiment, the first switch **120** can select either the semiconductor package **110a** or the semiconductor package **110b**, in response to an enable signal. Thus, either the semiconductor package **110a** or **110b** can be considered to determine equivalent resistances of all components connected to the controller **130**. Also, either the semiconductor package **110a** or **110b** can be considered to determine equivalent resistances of all components connected to each of the semiconductor packages **110a** and **110b**.

Thus, even if the total number of semiconductor packages is increased, a loading effect may be prevented from occurring. Accordingly, it is possible to prevent signal integrity from being degraded due to the loading effect.

The memory system **100a** may further include a plurality of bi-directional buffers **170**.  $N$  bi-directional buffers **170** may connect the first signal lines **140a** and **140b** to the first switch **120** in an  $N$ -to-1 correspondence, e.g., in a 2-to-1 correspondence when  $N$  is '2'. Each of the bi-directional buffers **170** may include a first repeater **180a** having an input terminal connected to the first switch **120** and an output terminal connected to the first signal lines **140a** and **140b**, and a second repeater **180b** having an input terminal connected to the first signal lines **140a** and **140b** and an output terminal connected to the first switch **120**. When a data signal that is to be transmitted to the first and second signal lines **140a**, **140b**, and **150** attenuates, the first and second repeaters **180a** and **180b** may reproduce and transmit the data signal.

The switch **120** may include first I/O terminals **120a**, **120b** to connect to the bi-directional buffers **170** and an a second I/O terminal **120c** to connect to the controller package **130**.

FIG. 1B illustrates a memory system **100b** similar to the memory system **100a** of FIG. 1A, but without the bi-directional buffers **170**.

FIG. 1C illustrates a memory system **100c** according to another embodiment of the present general inventive concept. The memory system **100c** includes the semiconductor memory packages **110a** and **110b**, switch **120**, and controller **130** illustrated in FIG. 1A. However, in FIG. 1C, the signal line **150**, or I/O line, is connected to an I/O unit **190** that is separate from the controller package **130**. The I/O unit **190** may be an I/O terminal, I/O buffer, memory, logic, or other circuitry to transmit data to and from the semiconductor packages **110a**, **110b** via the switch **120**.

FIG. 1C illustrates a memory system **100c** in which the controller package **130** transmits a selection signal to the switch **120** on a selection signal line **161** that is different from the selection lines **160a**, **160b**. However, one or more of the selection lines **160a**, **160b** may be connected to the switch **120** to act as a selection signal for the switch **120**.

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FIG. 1D illustrates a memory system **100d** in which the controller package **130** transmits a selection signal **161** to the switch **120** and an address signal **160c**, or a control signal, to the semiconductor packages **110a**, **110b**. Although only one address signal line **160c** is illustrated in FIG. 1D, a separate address signal line **160c** may be connected to each semiconductor package **110a**, **110b** if desired. In the embodiment illustrated in FIG. 1D, the semiconductor chips **110a**, **110b** may be read-only memory. The semiconductor chips **110a**, **110b** may be continuously enabled and outputting a signal to the switch **120** based on the address signal of the address signal line **160c** from the controller package **130**. The selection signal line **161** transmits a selection signal to select from which chip **110a**, **110b** the controller package **130** will receive data.

FIG. 1E illustrates a memory system **100e** in which the controller package transmits an read/write enable signal R/WE to a memory semiconductor package **111** via a signal line **160e** to indicate to the memory semiconductor package **111** whether the memory semiconductor package will output data to the signal line **140a** in a read operation or receive data via the signal line **140a** in a write operation. The controller package **130** may also transmit an address signal ADDR via an address line **160c** to indicate a location on the memory semiconductor package **111** that is to be read from/written to.

A second semiconductor package **112** may include a logic circuit. The controller package **130** may output an enable signal EN to the logic semiconductor package **112** via the selection line **160b** to indicate to the logic semiconductor package **112** whether the logic semiconductor package **112** is to receive data via the I/O signal line **140b** or output data to the I/O signal line **140b**. The logic semiconductor package **112** may receive inputs  $I_1 \dots I_n$  on which to perform logic functions from the controller package **130** or from external sources via one or more input lines **160d**.

The controller package **130** may output a selection signal SEL to the switch **120** to indicate which semiconductor package **111**, **112** will perform a read/write function with the controller package **130** via the signal lines **140a**, **140b**, and **150**.

Although FIGS. 1A-1E illustrate various example embodiments of the present general inventive concept, any memory and/or logic circuit including a variety of data, address, enable, and selection inputs may be used. Data, address, and command inputs may be originated at the controller package **130**, for an external source, or from any combination of the two. The semiconductor packages may be read-only, read/write, write-once, logic, or any other appropriate semiconductor package. The semiconductor packages may also be external to the printed circuit board **50**, so that different semiconductor chips may be connected to the switch **120** via terminals. Likewise, any portion of the controller package **130** may be external to the printed circuit board **50** and connected to the switch **120** and semiconductor packages via terminals.

FIG. 2 is a schematic diagram of a memory system **200** according to another embodiment of the present general inventive concept. The memory system **200** may be a modified embodiment of the memory system **100** illustrated in FIG. 1. The operations and constructions of the elements of the memory system **200** that are the same as those of the elements of the memory system **100** will not be described again here.

Referring to FIG. 2, the memory system **200** may include second switches **125a** and **125b**. The second switches **125a** and **125b** may be mounted on a printed circuit board **50**. The second switches **125a** and **125b** may sense enable signals



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from selection lines **160a** and **160b** and electrically connect first signal lines **140a** and **140b** to a second signal line **150**, respectively.

N first signal lines may connect N semiconductor packages in a 1-to-1 correspondence. For example, when N is '2', the first signal lines **140a** and **140b** may connect the semiconductor packages **110a** and **110b**, respectively, so that the first signal lines **140a** and **140b** and the semiconductor packages **110a** and **110b** are in a 1-to-1 correspondence. The first signal lines **140a** and **140b** may transmit a data signal to be stored in or to be loaded from the semiconductor packages **110a** and **110b**.

The second signal line **150** may be connected to the second switches **125a** and **125b** to a controller **130**, respectively. The second signal line **150** and the first signal lines **140a** and **140b** may be electrically connected via the second switches **125a** and **125b**, respectively. The second signal line **150** may transmit data signals from the first signal line **140a** or the second signal line **140b** to the controller **130** and vice versa.

N selection lines may connect N semiconductor packages to N second switches in a 1-to-1 correspondence. For example, when N is '2', the selection lines **160a** and **160b** may connect the semiconductor packages **110a** and **110b** to the second switches **125a** and **125b**, respectively, so that the semiconductor packages **110a** and **110b** and the second switches **125a** and **125b** are in a 1-to-1 correspondence. Also, the N selection lines may connect the N semiconductor packages to the controller **130** in an N-to-1 correspondence. For example, when N is '2', the selection lines **160a** and **160b** may connect two semiconductor packages **110a** and **110b** to the controller **130**, so that two semiconductor packages **110a** and **110b** and the controller **130** are in a 2-to-1 correspondence. The selection lines **160a** and **160b** may deliver enable signals from the controller **130** to the semiconductor packages **110a** and **110b**, respectively.

For example, if N selection lines, e.g., the selection lines **160a** and **160b** when N is '2', are respectively connected to N semiconductor packages, e.g., the semiconductor packages **110a** and **110b** when N is '2', then an enable signal transmitted via the selection line **160a**, which is located leftmost among the selection lines **160a** and **160b**, may go low. In this case, the second switch **125a**, which is located leftmost among the second switches **125a** and **125b** may sense the enable signal transmitted via the selection line **160a**, and may electrically connect the signal line **140a**, which is located leftmost among the first signal lines **140a** and **140b**, to the second signal line **150**. Thus, a data signal may be stored in or loaded from the semiconductor package **110a**, which is located leftmost among the semiconductor packages **110a** and **110b**.

Similarly, if N semiconductor packages, e.g., the semiconductor packages **110a** and **110b** when N is '2', are respectively connected to N selection lines, e.g., the selection lines **160a** and **160b** when N is '2', then an enable signal transmitted via the selection line **160b**, which is located rightmost among the selection lines **160a** and **160b**, may go low. In this case, the second switch **125b**, which is located rightmost among the second switches **125a** and **125b**, may sense the enable signal transmitted via the selection line **160b** and may electrically connect the signal line **140b**, which is located rightmost among the first signal lines **140a** and **140b**, to the second signal line **150**. Accordingly, a data signal may be stored in or be loaded from the semiconductor package **110b**, which is located rightmost among the semiconductor packages **110a** and **110b**.

The memory system **200** may include a plurality of bi-directional buffers **170**. N bi-directional buffers, e.g., the

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bi-directional buffers **170** when N is '2', may connect the second switches **125a** and **125b** to the second signal line **150** in an N-to-1 correspondence, e.g., in a 2-to-1 correspondence.

The plurality of switches **125a**, **125b** may have I/O terminals **126a**, **126b** connected to the signal lines **140a**, **140b** and I/O terminals **127a**, **127b** connected to the buffers **170**.

FIG. 3 is a schematic diagram of a memory system **300** according to another embodiment of the present general inventive concept. The memory system **300** may be a modified embodiment of the memory system **200** illustrated in FIG. 2. The operations and constructions of the elements of the memory system **300** that are the same as those of the elements of the memory system **200** will not be described again here.

The memory system **300** may further include a plurality of bi-directional buffers **170**. N bi-directional buffers may connect N first signal lines to N second switches in a 1-to-1 correspondence. For example, when N is '2', two bi-directional buffers **170** may connect two first signal lines **140a** and **140b** to two second switches **125a** and **125b**, respectively, so that the first signal lines **140a** and **140b** and the second switches **125a** and **125b** are in a 1-to-1 correspondence.

The plurality of switches **125a**, **125b** may have I/O terminals **126a**, **126b** connected to the buffers **170** and I/O terminals **127a**, **127b** connected to the signal line **150**.

While the above embodiments illustrated in FIGS. 1A-3 each have different elements, the present general inventive concept is not limited to the memory systems illustrated in these figures. Elements from any Figure may be combined with elements from another Figure. For example, a memory system having no buffer circuitry, as illustrated in FIG. 1B, may be combined with a memory system having a logic semiconductor package, as illustrated in FIG. 1E. Any other combination of circuitry may be used, depending on the design requirements of the circuit.

FIG. 4 is an eye diagram **400** comparing signals that are input to or output from a conventional memory system in which first signal lines are connected directly to a second signal line without a first switch with signals that are input to or output from one of memory systems according to embodiments of the present general inventive concept.

Eye window sizes **410a**, **410b**, **410c**, and **410d**, each representing the degree of signal interference caused by distortion of a transmission path, may be compared to estimate channel performance. The eye window size **410a** of the conventional memory system is 2.34 ns at 133 Mbps, whereas the eye window size **410b** of one of the memory systems according to the embodiments of the present general inventive concept is 5.01 ns at 133 Mbps. Thus, the eye window size **410b** of one of the memory systems according to the embodiments of the present general inventive concept is increased by about 114 percent compared to the eye window size **410a** of the conventional memory system.

The eye window size **410c** of the conventional memory system is 5.26 ns at 100 Mbps, whereas the eye window size **410d** of one of the memory systems according to the embodiments of the present general inventive concept is 7.56 ns at 100 Mbps. Thus, the eye window size **410d** of the memory systems according to the embodiments of the present general inventive concept is increased by about 44 percent compared to the eye window size **410c** of the conventional memory system.

Jitter represents change in the cycle of a signal frequency from a target timing location and may be considered in order to estimate a deviation or variation in phases of waves in a high-frequency domain. A jitter **420a** generated in the conventional memory system is 2.36 ns at 133 Mbps, whereas a

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jitter **420b** generated in one of the memory systems according to embodiments of the present general inventive concept is 1.43 ns at 133 Mbps. Thus, the jitter **420b** in one of the memory systems according to the embodiments of the present general inventive concept is reduced by about 39 percent compared to the jitter **420a** in the conventional memory system.

A jitter **420c** generated in the conventional memory system is 1.63 ns at 100 Mbps, whereas a jitter **420d** generated in one of the memory systems according to embodiments of the present general inventive concept is 1.38 ns at 100 Mbps. Thus, the jitter **420d** in the memory systems according to the embodiments of the present general inventive concept is reduced by about 15 percent compared to the jitter **420c** in the conventional memory system.

Accordingly, in the memory systems according to the embodiments of the present general inventive concept, the total number of memory chips that can be connected to a controller may be increased without degrading signal integrity (SI) characteristics. That is, the memory systems according to the embodiments of the present general inventive concept may have greater storage capacity than those of conventional memory systems, the operating speeds of which are equal to those of the memory systems according to the embodiments of the present general inventive concept.

FIGS. 5 and 6 are, respectively, a block diagram of and a plane view of a memory device **500** having a memory system **100** according to embodiments of the present general inventive concept. Referring to FIGS. 5 and 6, the memory device **500** may include the memory system **100**, a buffer **510**, and a host interface **520**. The memory system may include the controller **130**, the memory packages **110**, and the first switch **120** or the second switches **125a** and **125b** as described above.

The memory device **500** may include an SSD, a memory module, a memory card, a memory semiconductor package, or a combination thereof. In particular, the memory card may be a personal computer memory card international association (PCMCIA) card, a compact flash (CF) card, a smart media card (SM/MMC), a memory stick, a multimedia card (MMC, RS (reduced-size)-MMC, or MMCmicro), an SD card (SD, mini SD, or micro SD), a universal flash storage (UFS) device, or a combination thereof.

The host interface **520** communicates with the host **530**. That is, the host interface **520** may receive data to be written to the memory system **100** from the host **530** or may transmit data loaded from the memory system **100** to the host **530**. The host interface **520** may include protocols to exchange data between the host **530** and the memory system **100**. The protocols may include, for example, a universal serial bus (USB), a multimedia card (MMC), a peripheral component interconnect express (PCI-E), advanced technology attachment (ATA), serial-ATA, parallel-ATA, a small computer systems interface (SCSI), an enhanced small disk interface (ESDI), and integrated drive electronics (IDE).

The buffer **510** is connected between the memory system **100** and the host interface **520**. The buffer **510** may temporarily store data to be written to or to be loaded from the memory system **100**.

In the memory device **500** or the memory system **100**, various types of memory packages may be mounted on the printed circuit board **50** of FIG. 1, 2, or 3. The various types of memory packages include a package on package (POP), a ball grid array (BGA), a chip scale package (CSP), a plastic leaded chip carrier (PLCC), a plastic dual in-line package (PDIP), a chip on board (COB), a ceramic dual in-line package (CERDIP), a metric quad flat package (MQFP), a thin quad flat package (TQFP), a system in package (SIP), a multi

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chip package (MCP), a wafer-level fabricated package (WFP), a wafer-level processed stack package (WSP), and so on.

FIG. 7 is a block diagram of a computing system **600** having the memory device **500** of FIG. 5, according to an embodiment of the present general inventive concept. Referring to FIG. 7, the computing system **600** may include a central process unit (CPU) **610**, a random access memory (RAM) **620**, a user interface (UI) **630**, a power source **640**, and the memory device **500**.

The memory device **500** is electrically connected to the CPU **610**, the RAM **620**, the UI **630**, and the power source **640** via a system bus **650**. Data that is provided via the UI **630** or that is processed by the CPU **610** is stored in the memory device **500**. The memory device **500** may be embodied as an SSD, and in this case, the booting speed of the computing system **600** may increase greatly. Although not shown in the drawings, the computing system **600** may further include an application chipset, a camera image processor, etc.

FIG. 8 illustrates an example of a controller package **130** according to an embodiment of the present general inventive concept. The controller package **130** may include a logic unit **810**, a processing unit **820**, a memory unit **830**, an interface unit **840**, or any combination of these units. The logic unit **810** may include a programmable logic unit, such as an field programmable gate array, or non-programmable logic. The logic unit **810** may output data to or receive data from I/O lines **150** or may be configured to control an enable line **161** or a read/write command line (not shown). The logic unit **810** may also be configured to transmit data to and from any one of the processing unit **820**, memory unit **830**, and interface unit **840**.

The processing unit **820** may control operation of the logic unit **810**, memory unit **830**, and interface unit **840**. The processing unit **820** may also transmit and receive data via the I/O lines **150** or transmit data via the switch enable line **161** and the chip enable and address lines **160a-160c**. The processing unit **820** may receive data from any one of the logic unit **810**, interface unit **840**, memory unit **830**, and I/O lines **150** to process and transmit to any other of these units or lines.

The memory unit **830** may comprise read-only memory, flash memory, cache memory, or any other appropriate type of memory. The memory unit **830** may be configured to output data to or receive data from any one of the I/O lines **150**, logic unit **810**, processing unit **820**, and interface unit **840**. The memory unit **830** may store instructions, addresses, operation code, or any other data.

The interface unit **840** may comprise an I/O terminal such as a pin, port, wire, antenna, or any other means to interface with another device via a wire or wirelessly, including via RF waves, IR waves, or any other wireless method. The interface unit **840** may include memory or logic, or may use the memory unit **830** and logic **810** of the controller package **130**.

The controller package **130** may be an IC formed of a single chip, mounted on a same circuit board, or may include chips and electrical components on various circuit boards or in various devices that are connected to form a controller package **130**. For example, a processing unit **820** may be mounted on a same printed circuit board **50** as a switch **120**, but a memory unit **830** accessed by the processing unit **820** may be electrically connected to the processing unit **820** via a terminal.

As discussed above, the controller **130** may include a control logic unit to control the overall operations of the memory system **100**. The control logic unit may include, for example, a read/write circuit that stores a data signal in the semiconductor package **110a** or **110b** or loads a data signal from the

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semiconductor package **110a** or **110b**, and an address decoder that decodes an address received from the outside and provides the decoded address to the read/write circuit. The control logic unit may be the processing unit **820**, the logic unit **810**, or any combination of parts or functions of the units **810**, **820**, **830**, and **840** of the controller **130**.

While the present general inventive concept has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

What is claimed is:

1. A memory device, comprising:  
at least two semiconductor packages;  
a switch connected to each of the semiconductor packages via at least two first I/O lines, each first I/O line connected to a separate semiconductor package; and  
a controller connected to the switch via a single second I/O line and to each of the switch and the at least two semiconductor packages via an enable line,  
wherein the controller controls the switch to transmit data between only one of the first I/O lines and the second I/O line.
2. The memory device according to claim 1, wherein the at least two semiconductor packages comprise memory semiconductor chips.
3. The memory device according to claim 1, wherein at least one of the semiconductor packages comprises a logic semiconductor chip.
4. The memory device according to claim 1, wherein the switch comprises at least two switches, each switch connected to a single semiconductor package and each semiconductor package connected to only one switch,

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the enable line comprises at least two enable lines, and each semiconductor package and corresponding switch is connected to a same enable line that is separate from an enable line connected to any other semiconductor chip.

5. The memory device according to claim 1, wherein the switch comprises only one chip.
6. The memory device according to claim 1, further comprising:  
bi-directional buffers connected between the semiconductor packages and the switch.
7. The memory device according to claim 1, further comprising:  
bi-directional buffers connected between the switch and the controller package.
8. A memory device, comprising:  
at least two semiconductor packages;  
a switch connected to each of the semiconductor packages via at least two first I/O lines, each first I/O line connected to a separate semiconductor package of the two semiconductor packages; and  
a controller connected to the switch via an enable line and a second I/O line, and to the at least two semiconductor packages via at least one control line,  
wherein the controller controls the switch via the enable line to transmit data between only one of the first I/O lines and the second I/O line.
9. The memory device according to claim 8, wherein the control line comprises at least one of a read/write control line, an address line, and a chip enable line.
10. The memory device according to claim 8, wherein at least one of the semiconductor packages is a logic circuit including at least one terminal to receive a data input from a device external to the memory device.
11. The memory device according to claim 8, wherein the second I/O line is connected to at least one of a logic circuit, a memory chip, a processor, and an I/O port.

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